Comparison of JERS-1 SAR and SPOT-2 Panchromatic Data over a Semi-Arid Zone in Central Australia

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ABSTRACT

Analyses of the data observed with JERS-1 SAR and SPOT-2 panchromatic mode over a semi-arid zone in central Australia under a similar environmental condition indicate that (1) the high resolution data are useful for detection of small gullies or a degraded area caused by rare floods, (2) the narrow woody space in a widely bare land can be recognized in SAR data while not in the panchromatic data and (3) land cover classification image can be made with SAR data and panchromatic data.

INTRODUCTION

In cooperative research projects on desertification with China and Australia, it has been found that desertification is taking place in comparatively narrow spatial scale, and the high resolution satellite data are very useful for desertification studies [1]-[5]. In general analyses, the desertification is detected as the change of vegetation in semi-arid and arid zone, and SPOT-2 multi-spectral and JERS-1 OPS (OPtical Sensor) data are available for vegetation analyses while the spatial resolutions are 20m*20m and 24m*18m respectively. SPOT-2 panchromatic data is also useful with 10m spatial resolution while the vegetation analysis is difficult. These above mentioned satellite data, however, have a disadvantage since the chance of getting cloud-free data is very small. On the other hand, JERS-1 SAR (Synthetic Aperture Radar) data is very useful with 12.5m spatial resolution while the speckle noise and geometric distortion are the disadvantage since the data getting whole weather conditions and also getting day and night. The analyses of the high resolution data observed by JERS-1 SAR and by SPOT-2 panchromatic over a semi-arid zone of central Australia will be reported in the following sections.

THE ANALYSES OF THE DATA

Figure 1(a) and (b) are satellite images of JERS-1 SAR (August 20 1992) and SPOT-2 panchromatic (July 22 1992) respectively. In 1992, it was no precipitation from June 13th through August 26th. Furthermore the observation time difference of both satellites is within 30 minutes thus it is considered that the surface condition of two images was almost same.

Registration of the Data

Following procedures are taken to register two images with different resolution.

(1) For speckle noise reduction, the median filtering (window size: 5*5) is performed for SAR data.
(2) Taking SPOT-2 panchromatic image (10m resolution) as reference, 50 GCP's (Ground Control Points) are selected in JERS-1 SAR (12.5m resolution) image.
(3) Twenty Affine coefficients in Eq.(1) are computed [6].

$$p = a_0 + a_1*P + a_2*L + a_3*P*L + a_4*P^2 + a_5*L^2 + a_6*P^2*L + a_7*P*L^2 + a_8*P^3 + a_9*L^3$$
$$l = b_0 + b_1*P + b_2*L + b_3*P*L + b_4*P^2 + b_5*L^2 + b_6*P^2*L + b_7*P*L^2 + b_8*P^3 + b_9*L^3 \quad (1)$$

where, P and L are pixel and line numbers of a GCP of JERS-1 SAR while p and l are those of SPOT-2 panchromatic in pixel-line coordinate system. Although the equation must be solved under the condition that the average error becomes 0, in reality the absolute error cannot become zero.
(4) Moving one GCP in 8 directions (up-down, right-left, diagonal) and selecting one which minimizes the absolute and root mean square (RMS) errors, the process is repeated until the errors become negligibly small.

Correlation of the Whole Data

Figure 2 indicates the relation between Normalized Radar Cross Section (NRCS) of JERS-1 SAR data and radiance of SPOT-2 panchromatic data. The values of NRCS and that of radiance are compute from Eq.(2) and Eq.(3) respectively [7],[8].

$$\text{NRCS} = 20 * \text{Log}_{10}(X) - 70.5 \quad [\text{dB}] \quad (2)$$

$$\text{Radiance} = (X/A + B) * \cos(Z) * C \quad [\text{W/m}^2/\text{Sr}] \quad (3)$$

where X, A, B,C and Z denote digital counts recorded on CCT's(Computer Compatible Tapes), gain for conversion from digital counts into radiance, offset, solar zenith angle and bandwidth respectively. The coefficient of correlation between NRCS and radiance is -0.29. Next, the NRCS for undulating area such as hill or mountain is distributed as higher signal and that for flat area is distributed as lower one. Here the forward slopes of mountains make the maximum NRCS. On the other hand, the radiance for bare land and woody space are distributed as higher and lower reflectance respectively.

Detail Analysis for a Line Data

Figure 3 indicates the detail analysis of NRCS of JERS-1 SAR and radiance of SPOT-2 panchromatic data. From Figure 3 it can be seen that the trees are recognizable well in SAR data while not in the panchromatic data, approximately 10 meter width road is recognizable while in case of panchromatic data due to similar reflectivity of the unpaved road and surrounding bare land it is not possible to recognize. The very small gullies of 30 - 50cm order made by floods are detected in SAR data while not in the panchromatic data.

Land Cover Classification

Figure 4 indicates the land cover classification with JERS-1 SAR and SPOT-2 panchromatic data over the area shown in Figure 1 in four categories of woody space, dense grass land, sparse grass land (including small gullies or land degraded area caused by rare floods) and bare land. Following procedures are taken to make the image of land cover classification.

(1) For simplifying the threshold level selection, transform the JERS-1 SAR and SPOT-2 panchromatic data shown in Figure 1. into ten levels data with Ohtsu's threshold selection method since the method is automatically selected the minimum error thresholding levels [9],[10].
(2) Selecting the two threshold levels (PAN_H and PAN_L) for classifying the panchromatic data into three categories as bare land, grass land and woody space.
(3) Selecting the one threshold level (SAR_M) for classifying the SAR data into two categories as undulating area (such as woody space, hill or mountain) and flat area (such as grass land or bare land).
(4) Firstly, classifying into four categories of woody space, dense grass land, sparse grass land and bare land with two-dimensional multi-level slice method (pallarelpiped classification) while a little overlapping area cannot be classified. The classification are made as following roles:

IF	PAN≦PAN_H	&&	SAR>SAR_M	THEN	WOODY SPACE
IF	PAN≦PAN_L	&&	SAR≦SAR_M	THEN	DENSE GRASS LAND
IF	PAN_L≦PAN≦PAN_H	&&	SAR≦SAR_M	THEN	SPARSE GRASS LAND
IF	PAN>PAN_H	&&	SAR≦SAR_M	THEN	BARE LAND
IF	PAN>PAN_H	&&	SAR>SAR_M	THEN	ERROR (SPECKLE NOISE)

(5) Secondly, the classification for the overlapping area are made with Mahalanobis's minimum distance method.

From Figure 4 some small gullies and degraded area caused by rare floods are detected. Furthermore the narrow woody space in widely bare land and the sparse grass land can be recognized while not in the panchromatic data. These features are comforted in situ survey and aerial video data.

CONCLUDING REMARKS

From the analyses in this study following conclusions were obtained. The high resolution data such as JERS-1 SAR (12.5m resolution) and SPOT-2 panchromatic (10m resolution) data are very useful for the detailed analyses of ground surface condition. The land cover classification image was also made with synthesized those two data. The accurate classification method with SAR data will be considered as future works.

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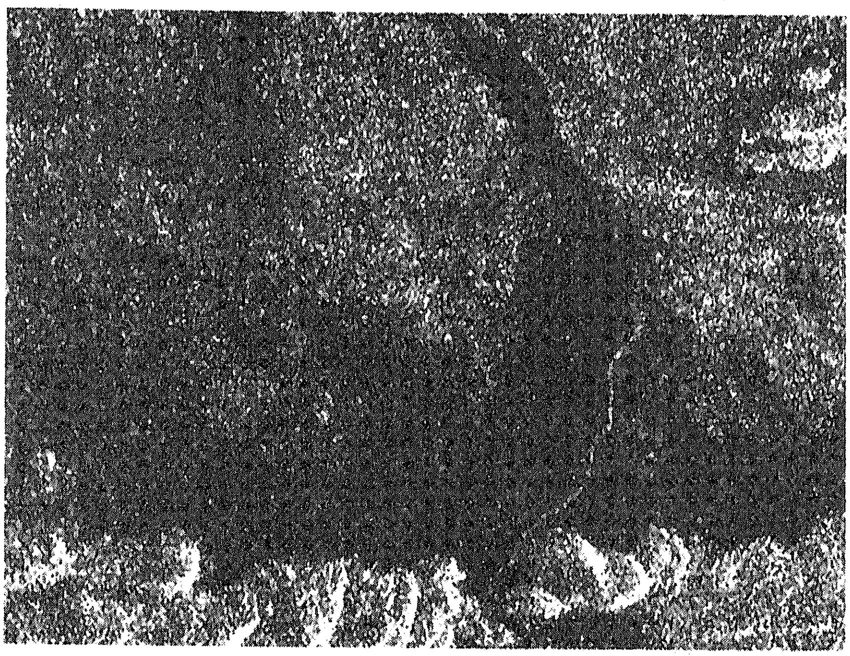
* Original text in Japanese.
**Original text in Japanese with summary, table and figure captions in English.

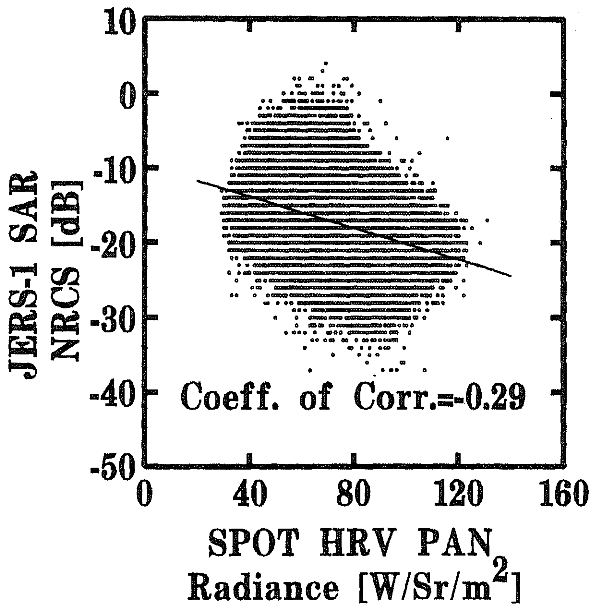
(a)



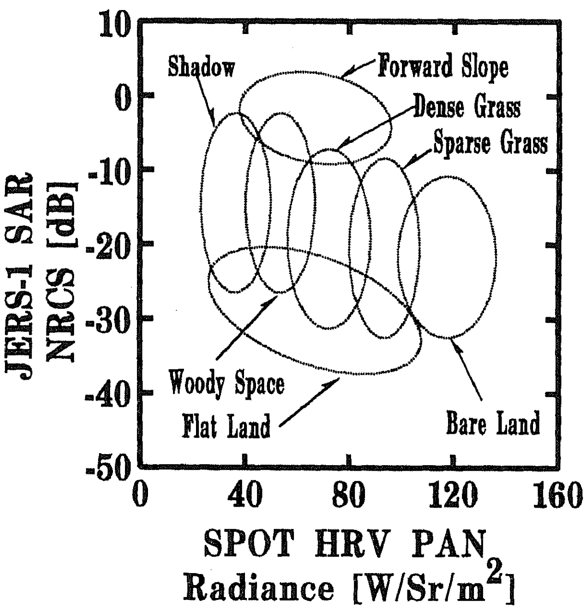
500m

(b)

Fig. 1. Satellite images of (a) JERS-1 SAR (August. 20 1992) and (b) SPOT-2 panchromatic (July 22 1992). The center at 23.34N/133.35E in central Australia.



(a) Correlation



(b) Distribution

Fig. 2. Relation between Normalized Radar Cross Section (NRCS) of JERS-1 SAR data and radiance of SPOT-2 panchromatic data.

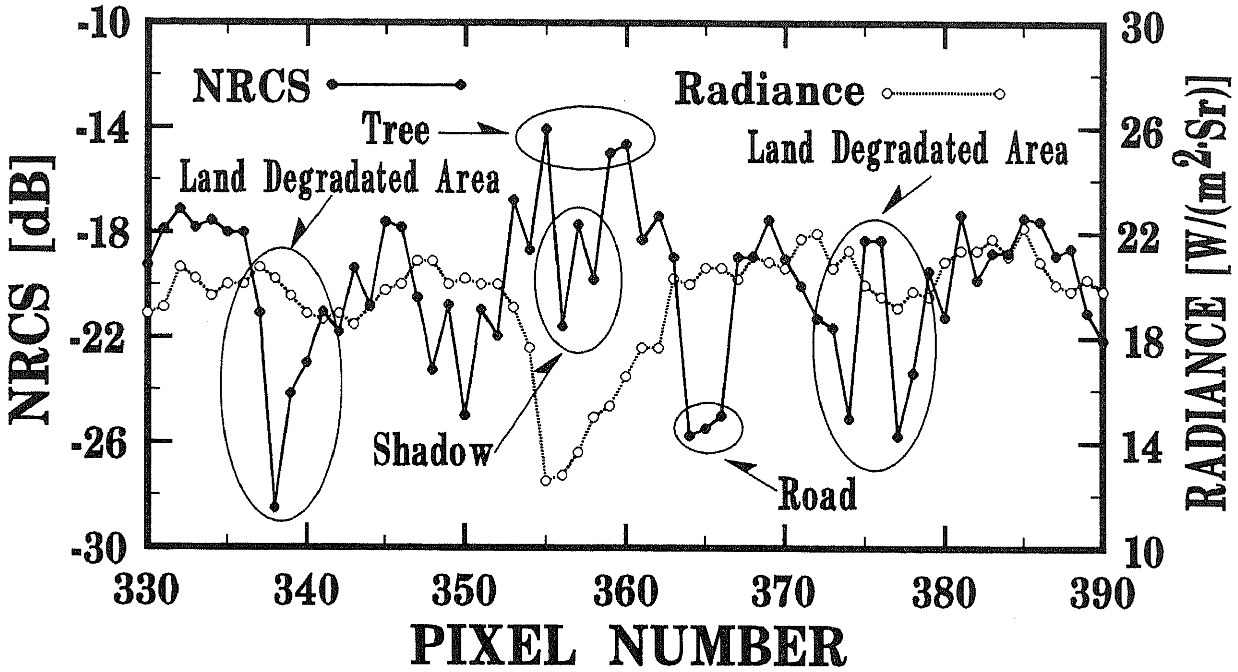


Fig. 3. Indicates the Normalized Radar Cross Section of JERS-1 SAR observation and radiance observation of SPOT-2 panchromatic for a line data.

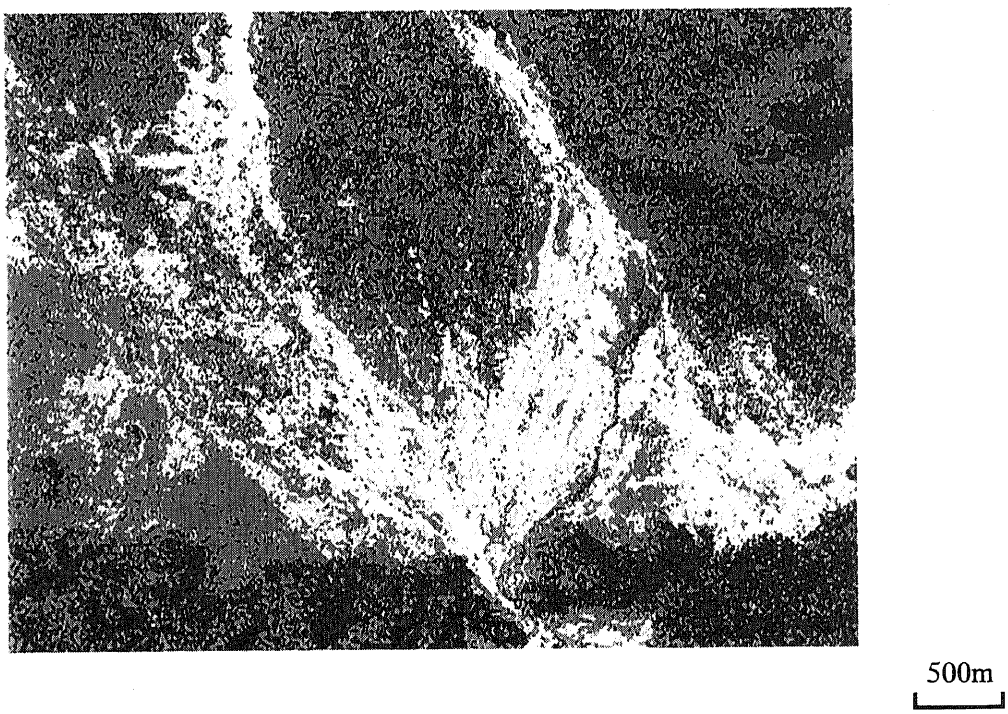


Fig. 4. Land cover classification over the area shown in Figure 1 in four categories of woody space, dense grass land, sparse grass land and bare land. The color schemes; (1) Black: woody, (2) Dark gray: dense grass land, (3) Bright gray: sparse grass land (including small gullies or land degraded area caused by rare floods) and (4) White: bare land.